GEOLOGY

Project title: The Search for Microbial Biomarkers in Terrestrial Deposits

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Objective: The primary purpose of this investigation is to evaluate the fossilization process and the potential for a long term record of the microbial life that exists associated with hot springs and their carbonate (travertine) and siliceous (siliceous sinter) deposits. Basically, we are looking for biomarkers (indicators that microbes once existed as part of the hot spring environment). This will allow us to determine the likelihood of finding fossilized microbes in extraterrestrial bodies, e.g., Mars, and what is the most likely preserved material. For example, will we have a better chance of finding body fossils or geochemical indicators of former organisms.

In order to carry out this investigation, we are analyzing the waters from which the mineral precipitates originate as well as the solid precipitates of carbonate (Mammoth Hot Springs) and siliceous sinter (Cistern Spring, Norris Geyser Basin). It is our intent to search for mineralogical (crystal habit, size, etc.) and geochemical (major, minor, and trace elements as well as isotopic) differences between biotically induced and abiotic precipitates as well as microbial remains (bacterial body fossils, biofilms, etc.).

Findings: Our work to date has indicated that biogenic compounds appear to break down relatively quickly in this hot environment and thus will not be well preserved in the ancient record. Some body fossil types, however, seem to display relatively good preservation potential.

Project title: Volcanology and Petrology of the Yellowstone Plateau Volcanic Field

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Objective: To understand the origins and eruptive mechanisms of late Cenozoic volcanic activity in the region of Yellowstone National Park and complete systematic geologic-mapping studies carried out intermittently in the park region since the 1960s.

Findings: No new work was done on this project in 2000.

Project title: Aqueous-Solid Geochemical Process Model of Travertine Precipitation at Angel Terrace, Mammoth Hot Springs, Yellowstone National Park

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Objective: This research will develop a quantitative process model that will incrementally track the diagenesis of hot spring travertine depositional facies from the modern through the Recent, Holocene, and Pleistocene. Resulting constraints on the rates and products of water-rock reactions provide the template necessary to accurately interpret travertine deposits in the early Earth and perhaps other planets. Travertines form where carbonate minerals precipitate near the vents of terrestrial hot springs, thus housing important information on water chemistry, hydrologic transport, climate, and microbial assemblages. There are, however, no systematic studies that offer guidance on how to interpret the complex crystalline fabrics and chemistries inherent to fossilized hot spring travertine. The model developed in this proposal will considerably improve our ability to extract original environmental information from ancient travertines by directly linking crystalline fabric and chemistry with original aqueous and post-depositional diagenetic processes.

Findings: The rate of crystal formation in each facies is dependent on CO2 degassing, temperature, pH, and microbial interactions. Crystal growth rates and patterns from two different pond facies have been measured in detail. Pond travertine varies in composition from aragonite needle shrubs ('fuzzy dumbbells') to rigid networks of ca1cite and aragonite. The first pond is located roughly 6 meters from the main vent along a secondary flow path. The temperature of this pond water varies from 39*C at the entrance to 37*C at the lip of the pond, while the pH ranges from 7.985 at the entrance to 8.092 at the pond lip. Isotope analysis of the pond water shows distinct positional variation, with dC13/dO18 values of (2.570, -16.720), (2.870, -16.720), and (2.340, -16.690), corresponding to the entrance, the center, and the lip of the pond. The travertine deposited showed significant variation with location within the pond. Average travertine precipitation was measured at 80 mm/day at the entrance, 50 mm/day at the center, and 125mm/day at the lip of the pond. The porosity of the deposits increased dramatically at the edges of the pond. The second pond, located roughly 2 meters away from the secondary vents along the main flow path, exhibits significantly different water chemistry and travertine deposition. In this second pond, the temperature varied from 60.9*C at the entrance to 58.5 *C at the lip, while the pH ranged from 7.320 to 7.385 over the same range. Travertine deposition at the lip of this pond was over 400 mm/day and contained a large degree of porosity. From the comparison of these two ponds, it is apparent that crystal growth is strongly correlated to water flow, temperature, and pH. From analyzing the crystal growth structures of travertine, it is possible to draw conclusions about the water chemistry at the time of deposition. With this understanding, it is possible to compare travertine deposition to other carbonate deposits, such as those contained within ALH-84001.

Project title: Mapping the Mineralogy, Vegetation and Microbiota of Yellowstone National Park Using Imaging Spectroscopy

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Objective: We are applying advanced remote sensing methods to map the distributions of vegetation (forest and nonforest species). Furthermore, we are applying these data to the mapping of microbial mats in the hydrothermal systems of Yellowstone, including the Upper and Lower Geyser Basins, Norris Geyser Basin, and Mammoth Hot Springs. In addition, the mineralogy of exposed rocks and soils on the surface are being characterized with this remote sensing data.

Findings: The results have successfully demonstrated the imaging spectroscopy using AVIRIS data can discriminate between the conifer cover types of Yellowstone. Specifically, the occurrences of whitebark pine, lodgepole pine, Douglas-fir, and a mixed Engelmann spruce/subalpine fir forest types were mapped in the park. The results showed that high altitude surveys by airborne spectrometers with 17 meter pixel size were able to distinguish microbial reflectance signatures from other materials. These unique signatures were used to map the occurrence of hot springs for selected flight lines over the park. Mineralogy of the hydrothermals systems, mapped by AVIRIS and the USGS Tetracorder system, revealed the different types of mineral alteration of bedrock in the park. For example, occurrences of carbonates, clays, alunite and siliceous sinter were identified.

Project title: Quaternary Geology and Ecology of the Greater Yellowstone Area

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Objective: To determine 1) the history of glaciation and distribution of glacial deposits; 2) the history of Yellowstone Lake and River level changes and related history of caldera inflation and deflation episodes; 3) the history of hydrothermal explosions, particularly in the Yellowstone Lake area; 4) geologic controls of plant ecology in the Greater Yellowstone area (with Don Despain and Ann Rodman); 5) the history of climate and fires, particularly by coring Crevice Lake; 6) the history of glacial and other floods, particularly along the Yellowstone River; 7) the history of faulting, particularly in the Mt Sheridan area, West Yellowstone Basin, and the upper Yellowstone Valley; and 8) to assist Interpretive staff in presentation of geologic topics to the public; and 9) evaluate the concept of the Yellowstone hot spot.

Findings: Nearly all of Yellowstone was glaciated during the last glaciation. During glacial buildup and recession, glaciers advanced from the surounding mountains onto the Yellowstone Plateau, whereas during full-glacial conditions, a large ice cap built up on the Yellowstone Plateau. Plant ecology is strongly controlled by geology, including lodgepole pine forests on the sandy, nutrient-poor rhyolite soils and areas of fine-grained glacial deposits largely in grasslands. Yellowstone Lake was below present levels about 3,000 years BP, and major rises in lake level occurred between 2,800 yr BP and present and between about 8,500 and 7,500 years BP.

Project title: Study and Monitoring of Selected Geyser Activity

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Objective: To study the activity of selected geysers in the Upper Geyser Basin, Lower Geyser Basin, and West Thumb Geyser Basin to determine the activity patterns during the study period. This information will provide baseline activity data for these geysers. A long-term record of geyser activity will be compared to other factors such as precipitation, lake level (for geysers near Yellowstone Lake) and activity of nearby geysers to determine possible influences of these factors on geyser activity.

Findings: During summer and fall 2000, nine electronic data loggers were deployed on geysers that have been monitored in previous years as part of this study and on some additional geysers. Data for all of the geysers was recorded, analyzed, and summary statistics and graphs of the activity for the monitoring period (June 24, 2000 through October 6, 2000) were prepared. Several of the loggers are deployed for the winter of 2000-2001. In a few cases, equipment failures caused loss of data. The following describes the geysers monitored and the years for which data are available: Aurum Geyser (1997-2000), Boardwalk Geyser (1998, 2000), Depression Geyser (1997-2000), Lion Geyser (1998-2000), Little Cub Geyser (1998-

2000), Plate Geyser (1998-2000), Pyramid Geyser (1995-2000), Lone Pine Geyser (1997-2000).

Data from 2000 indicates that Plate Geyser and Boardwalk Geyser are interconnected. Several Geyser Hill geysers show long-term (~5-7 days) variation in intervals. Intervals between eruptions of Lone Pine Geyser at West Thumb show some variation that may be related to lake level.

Software to extract eruption data from the temperature record was improved and extended this summer. All data files are archived on the Principal Investigator's computers and on NPS computers at YNP. Spreadsheets with all eruption times, statistics, and graphs are also available.